SILENCER

DESCRIPTION

The inventor has at his disposal essentially three different silencer types for muffling exhaust noises of internal combustion engines, especially of motor vehicle drives. Each type, namely Helmholtz resonators, dissipation silencers and absorption silencers, functions according to different physical principles.

A three-pipe exhaust silencer is known from the journal *Automotive Engineering*, June 1977, page 45, Figure 5, with relevant text from page 44, middle column, paragraph 2 to page 45, left column, paragraph 1. In this silencer three tracking (axle-parallel) gas-conducting pipe sections are aligned in a silencer housing in such a manner that they run through an axial sequence of two silencer housing chambers, each isolated gastight from the other. Each of the three pipe sections is equipped with openings into their respective silencer housing chambers.

The first, intake-side pipe section, oriented in the flow direction of the gas, is closed at the far end and provided with openings in front of this end area through which the exhaust can enter in a dissipative manner into a first silencer chamber, routed approximately at a right angle.

A second pipe section of the silencer, closed at both ends, opens into this first silencer chamber via a corresponding pipe wall perforation. The exhaust entering into the first silencer chamber enters through means of the perforation of the second pipe, again dissipatively and at a right-angle routing into the second pipe neck. Due to the two-time right-angle routing of the gas flow this now runs axially counter to the direction of the entering exhaust stream at the intake neck.

The exhaust, again routed at a right angle, enters dissipatively into a second silencer housing chamber at the exit section of the second pipe section, which is situated at the entry side of the silencer and is axially closed.

The entry section of the third pipe section, which is also closed at the ends, opens into this second housing chamber next to the end section of the second pipe section. The entry section of the third pipe section also has corresponding openings for gas entry. The exhaust, once again routed at a right angle and dissipatively, then leaves the silencer via a non-perforated exit section of the third pipe section.

The exhaust, thus conducted over an s-shaped route via three separate pipe sections through the exhaust silencer, is thus altogether dissipatively dampened by means of a 360-degree diversion.

This series of dissipative gas flow routings, however, means not only significant streaming losses in the exhaust flow but also the unavoidable appearance of overtone resonances (page 44, Fig. 3, upper curve).

For targeted filtering of such narrow interference frequency ranges the intake section of the third pipe section of the exhaust silencer known in the state of the art technology as shown in Fig. 4 on page 45 is configured as a Helmholtz resonator and tuned to the corresponding narrow interference bands. The intake section of the third pipe section of the known silencer thus functions together with the perforated exit of the second pipe section bifunctionally, namely as a dissipative reflection sound silencer as well as a Helmholtz resonator.

Constructions of this and of a similar nature work with flow losses in the exhaust stream and thus also with performance losses in the drive train. These losses may not be too significant for the V8 motor given in the state of the art example, but they are not, for example, compatible

with a 3-liter vehicle. They also evidence only moderately effective broadband dampening. Moreover, more pre- or post-inserted resonators are required for further resonance interferences, in order to effectively dampen all interference noises of a motor vehicle exhaust.

Proceeding from this state of the art, the invention is called upon to create broadband, specifically tunable silencers, especially for automotive technology, which in their improved sound dampening effectiveness do not practically diminish the performance of the aggregate drive and which can be very compact in size.

The invention solves this problem by means of an exhaust silencer which has the features named in Patent Claim 1.

Specifically, the exhaust silencer with the characteristics of the invention excels above all in the combination of two characteristics, namely in its design as a pure Helmholtz resonator with a series of more or less narrow and from chamber to chamber overlapping silencing frequency bands, which in fine-tuning also are accessible to an acoustic design, and on the other hand by a configuration of the gas-conducting exhaust pipe in the silencer housing in such a manner that it is led through each resonator chamber of the silencer housing at least twice, in some instances even thrice, without interruption and to the greatest extent possible without dissipation and without producing noticeable streaming losses in the exhaust flow. The curved pieces, designed with the largest possible radius and preferably running through the end of the last silencer chamber of the axial series of chambers, are to be considered equivalent to such a two- or three-time pass of the exhaust pipe through the chamber.

A significant increase in silencer performance is achieved by means of the running through of one and the same resonator chamber with identically tuned openings specifications of one and the same continuous exhaust conduit, without requiring either a second separate silencer

in series or parallel, or that the axial construction length of the silencer housing surrounding the chamber needs to be increased.

The sum of the advantages gained in this manner with the exhaust silencer according to the invention allows this silencer to offer the best characteristics, especially for the construction of terminal silencers.

In this construction the clear trend toward modularization in automotive construction can be joined, since the exhaust-conducting hole pipes of the Helmholtz resonator can be configured as modular parts, especially of die cast aluminum or plastic, of identical modular configuration with openings specifications variably tuned to the volumes required by the identical chamber configurations. This makes possible the flexible production of identical terminal silencers which can be tuned, for example, to various drives.

The invention is described in more detail below on the basis of a construction model in connection with the drawings.

Figure 1 shows a schematic representation of a section according to I-I in Figure 2; and

Figure 2 shows a section according to II-II in Figure 1.

The exhaust silencer shown in Figures 1 and 2 with the characteristics of the invention is comprised of a silencer housing 1, in which a U-shaped exhaust-conducting pipe 2 is placed centrally. The cross-section of pipe 2 is also shown ovally flattened, whereby the long axes of the cross-section of the housing 1 and of the cross-section of the pipe 2 are arranged coaxially to each other. At its intake end 3 the pipe 2 has an intake connector neck (not shown), on its exit end 4 an exit neck (not shown) for the exhaust flow through pipe 2.

Pipe 2 is provided with a number of openings 5, indicated only schematically in Figure 1.

The silencer housing 1 is subdivided into an axial series of silencer housing chambers 6, which are hermetically gastight separated from each other and from which each one relative to the others evidences a differing resonance volume. An axial shortening of the housing dimension is achieved by means of the radial two-level configuration of the silencer housing 1; the shortening is especially noticeable for the greater chamber volumes.

The openings 5 in the gas-conducting pipe 2 are so arranged that they open only into one chamber 6, thus do not bridge two contiguous chambers. In each of the individual chambers 6, communicating openings of the same specifications open into the interior of the gas-conducting pipe. The openings however are configured on the respectively axle-parallel [tracking] legs of the U-shaped pipe. This is however not true for the uppermost silencer housing chamber 6' with the greatest chamber volume shown in Figure 1, but is well-compensated by means of the relatively long curved piece and the dampening of the simultaneously deepest dampened frequencies in this range.

On the whole a nearly doubled silencing effect is achieved by means of the similarly doubled silencing surface in the silencing overall cross section, without the need for the silencer housing to be oversized.

In the manner evident from Figure 1, the gas-conducting pipe in the construction example shown here is U-shaped so that the intake side 3 and the exit side 4 of the exhaust silencer lie next to each other on an axial side of the exhaust silencer. According to a further form of the invention a further bend can be attached instead of the exit connection 4, which in a third run, for example above or below the cut level I-I in Figure 2 leads to the opposite deep-tone end of the

silencer housing and there provides an exit connection, so that intake 3 and exit 4' lie across from each other in the same flow direction to both ends of the exhaust silencer.

Both forms of the invention, the U-shaped pipe configuration as well as the S-shaped pipe configuration have in common that they evidence no manner of fittings, baffles, or abrupt flow direction changes, and in this manner lead only to minimal flow losses in the exhaust stream. This means that there are no noteworthy losses in motor performance, even given the unusually good and precise effectiveness, tunability and performance capability of the silencer according to the invention.

A further advantage of this arrangement is that in an extremely broad frequency band, due to the high number of individual silencer chambers in the silencer housing, a selective dampening of the exhaust noise can be undertaken according to the acoustical design with the most simple means, namely an adaptation of the openings characteristics in the exhaust pipe, i.e., an adaptation of cross-section and wall height.

The summary included with the description is a component of this disclosure.